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ABSTRACT

A guide for using an abacus is accompanied by a heavy-duty paper abacus. The guide includes instruction in how to represent numbers on an abacus as well as in place value, addition, carrying, subtraction, and borrowing. Diagrams are used throughout the guide and a brief English-Spanish vocabulary list specific to the use of the abacus is included. (MN)

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A USER'S GUIDE FOR THE FABULOUS ABACUS

by

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1. Introduction

In my work with migrant and Mexican-American children in grades 5-9 I have found the abacus to be one of the most useful devices available to teach the basic concepts of addition, subtraction, carrying, borrowing, and place-value. Unfortunately, the usual abacus is rather expensive and it may be impossible to equip each student in a class with one. To remedy this situation the Washington State Migrant Education Center is publishing an inexpensive abacus made out of heavy-duty paper and this "User's Guide" so that any teacher who wishes to equip his or her class with abacuses may do so.

A supply of abacuses and this "User's Guide" is available from the Washington State Migrant Education Center, Post Office Box 719, Suunyside, Washington 98944.

This type of abacus, in its mono-lingual version is due to Wayne Peterson of the Seattle Public Schools Basic Skills Office and the author wishes to acknowledge and thank Mr. Peterson for his contribution.

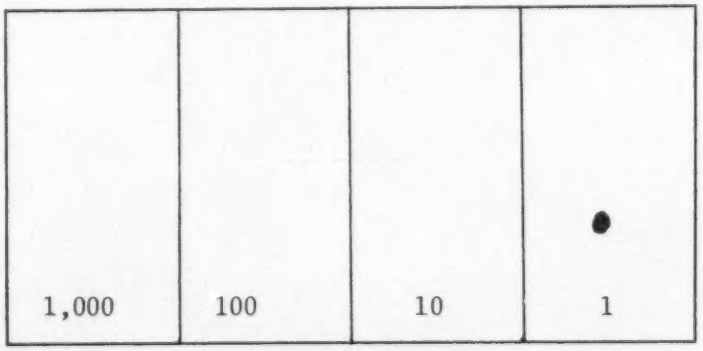
2. Getting Started

Equip each of your students with one copy of the abacus, and perhaps a ruler to allow for easier folding. One folds along the lines so that the solid lines end up at the bottom of valleys and the dotted lines on the top of ridges. The finished product should look like four long troughs connected together. In addition, the words one and unidades should share the right-most trough, ten and decenas the next, hundred and centanas the next and thousand and milares the left-most one.

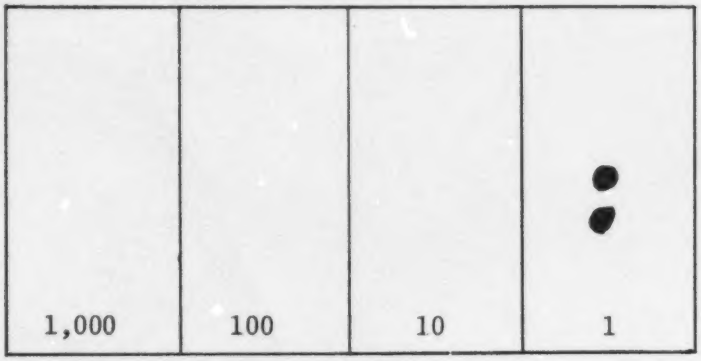
Issue each student about fifty counters (beans, small poker chips, stones, or bottle-caps are all possibilities), and you are ready to proceed. I have had some problems with students taking each other's counters, so the abacus is best used at individual desks rather than at large tables.

3. Representation of Numbers

It is impossible for a student to use an abacus without being able to represent numbers on it, so we begin there. One counter in the one trough represents the number 1,

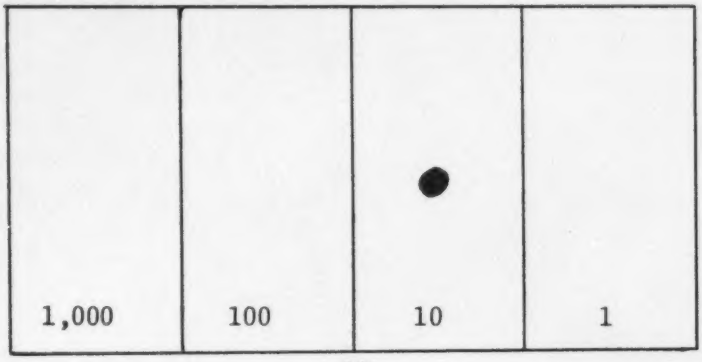


whereas two counters there represent the number 2,



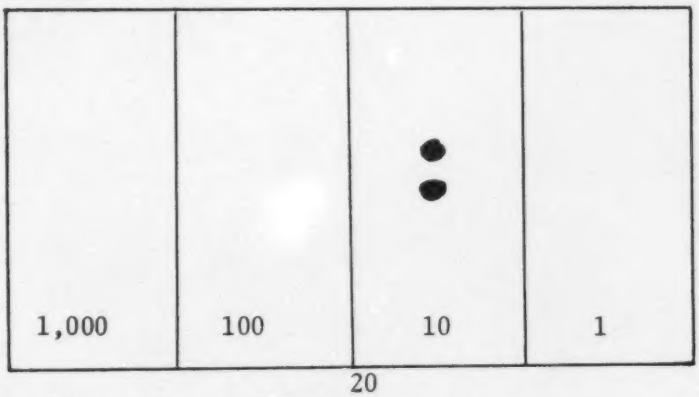
2

and so forth for three, four, five, etc. One counter in the ten trough represents the number 10,



10

two counters there means 2 x 10 or 20,

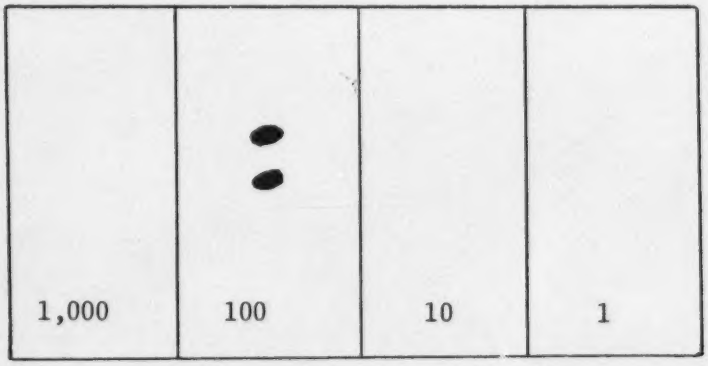


20

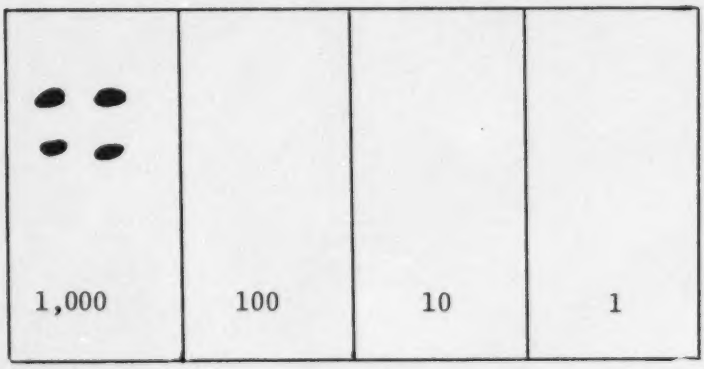
and similarly for thirty, forty, fifty, etc.

At this point, two important ideas should be stressed. First, the utility of the numeral 0 as a place-holder should be explained to the students. That is, one counter in the one trough and one in the ten trough represent two different numbers and because of the structure of the abacus, it is easy to distinguish them. However in writing the numbers 1 and 10 we need to show that the numeral 1 in 10 means "one ten" whereas the numeral 1 in 1 means "one one". Secondly, I want to emphasize that the student should write down everything he or she does on the abacus; the child must also record his calculations on paper in order to gain as quickly as possible the ability to calculate without the use of the abacus.

Continuing as before, one counter in the hundred (thousand) trough represents 100 (1000); two means 200 (2000); etc.

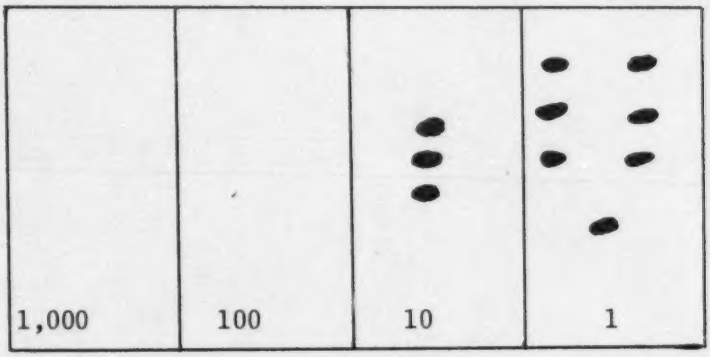


200



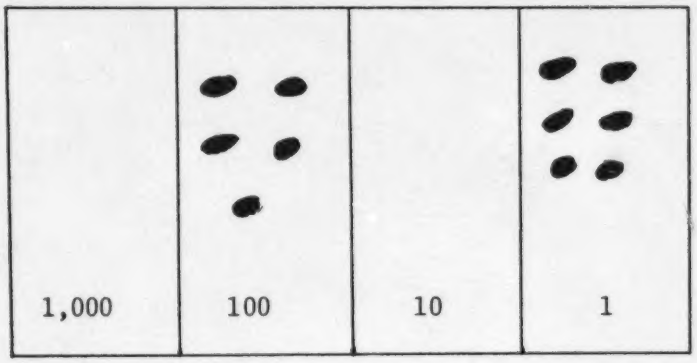
4,000

More complicated numbers, then, can be expressed as several counters in two or more troughs. For instance, 37 can be represented by three counters in the ten trough and seven in the one trough.



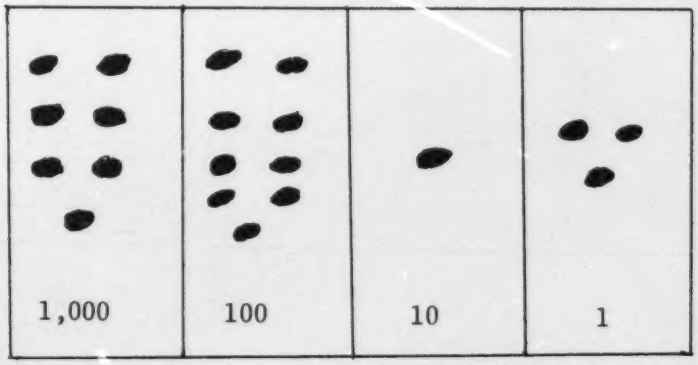
37

Five counters in the hundred trough and six in the one trough means 506.

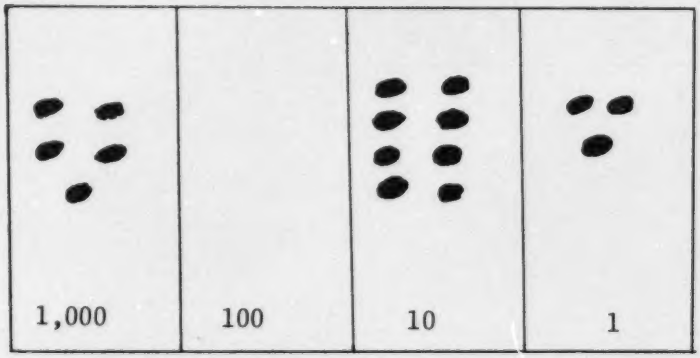


506

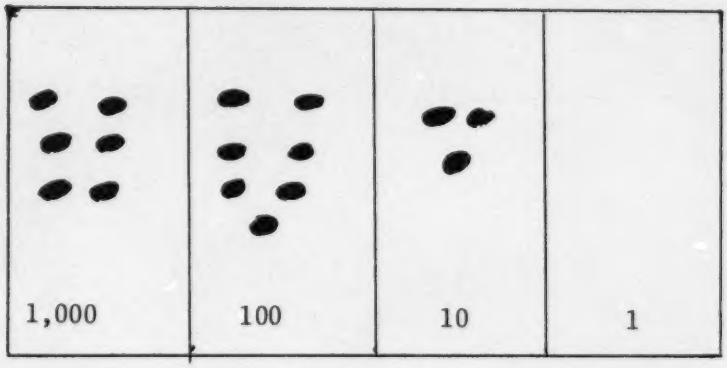
Illustrations of the representation of several other numbers follow:



7,913



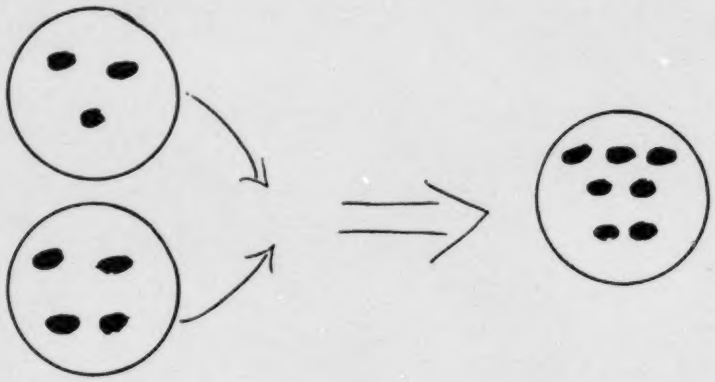
5,083



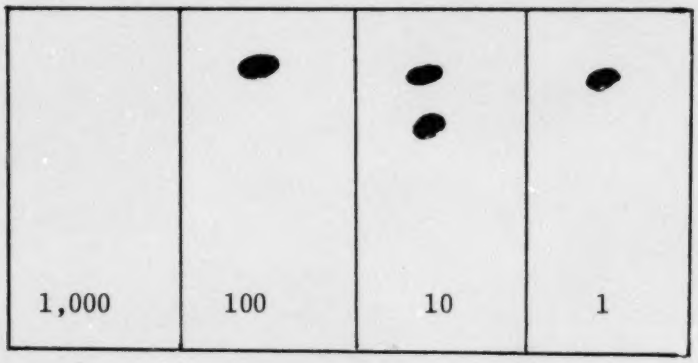
6,730

4. Addition

The use of the abacus to teach addition is particularly valuable since it reinforces the concept of addition we should like the student to have; the sum of 3 and 4, for example, is the number obtained by constructing a set containing 3 counters, one containing 4 counters, pushing them together, and counting the elements in the resulting larger set. It is extremely important that students have a mental image of the physical meaning of addition, rather than merely learning the addition facts as formal operations on a pair of numbers.

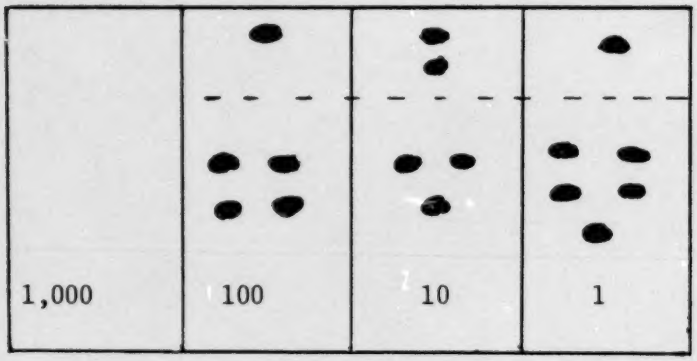


We begin with a discussion of the simple case of addition without carrying. This process is extremely simple. If one wishes to add two numbers, one represents the first on the abacus, leaves it in place while representing the second, and the sum is just the number whose representation then appears on the abacus. For example, suppose we wish to add 121 and 435. First 121 is placed on the abacus:



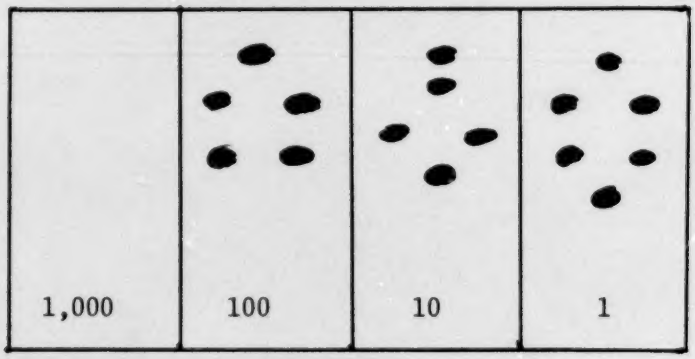
121

Then 435 is put on the abacus:



121 + 435

Finally the sum is read off as the number remaining on the abacus.

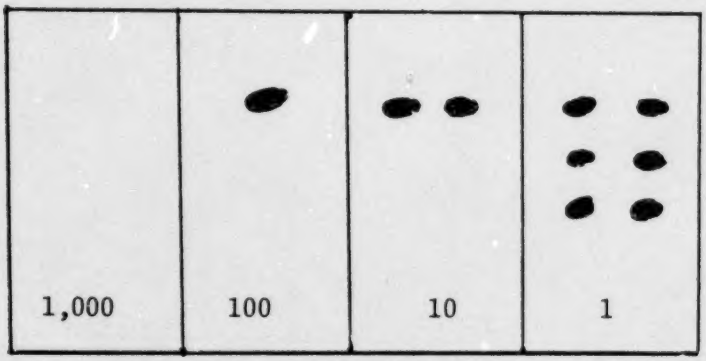


556

Remember: it is very important that the child write down each problem as he does it on the abacus:

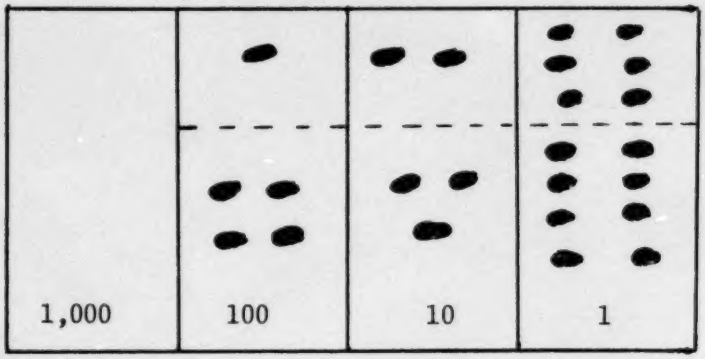
$$\begin{array}{r} 121 \\ +435 \\ \hline 556 \end{array}$$

Next we turn to the case where more than ten counters remain in one or more troughs of the abacus after the two numbers are entered. In this situation, renaming or carrying will be required. Suppose we wish to sum 126 and 438. As before, we first place 126 on the abacus:



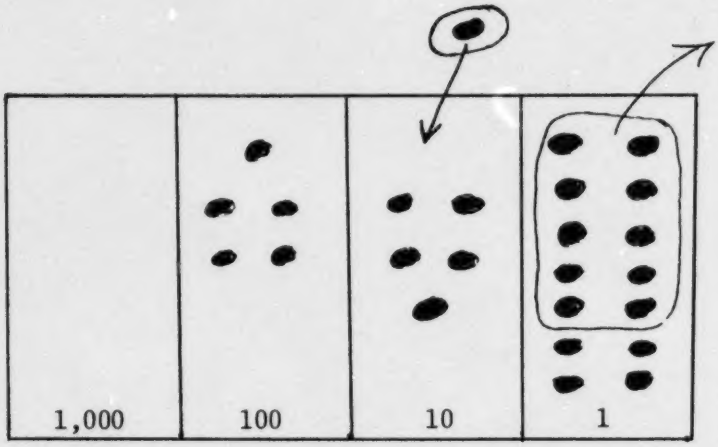
126

Next we place counters representing the number 438 on the abacus without removing the counters representing 126:

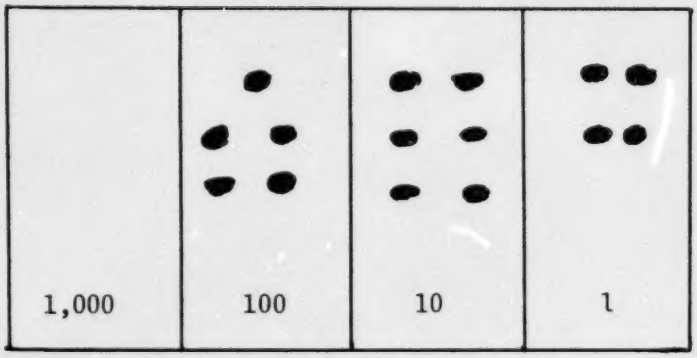


126 + 438 = 5 5 14

Observe that there are now 14 counters in the one trough. At this point one should explain to the students that the rules of the game do not allow more than nine counters in a trough when the answer is recorded and that the value of the number represented on the abacus will not change if ten counters in the one (ten, hundred) trough are removed and one counter is placed in the ten (hundred, thousand) trough.



This done, the final answer remains on the abacus.



564

As usual, the student should be encouraged to write down the complete problem and solution:

$$\begin{array}{r} (1) \\ 126 \\ +438 \\ \hline 564 \end{array}$$

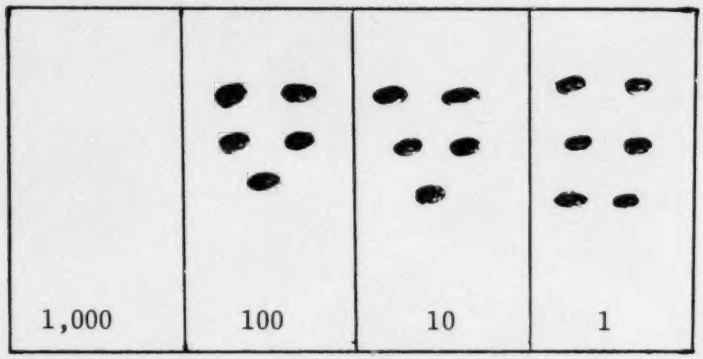
I shall not deal further with the various possible cases of carrying. It is sufficient to say that the same general principle holds in all such circumstances: ten counters in a smaller number trough can always be replaced by one in the next higher trough.

5. Subtraction

Subtraction is easily taught using the abacus, because a compelling concrete model is presented. That is, one begins with a large set of elements, say, for example, 9. This set is partitioned into two subsets, perhaps one of 3 elements and one of 6. Finally one subset, for example the one of six elements, is removed and the other left is the result of the subtraction problem.

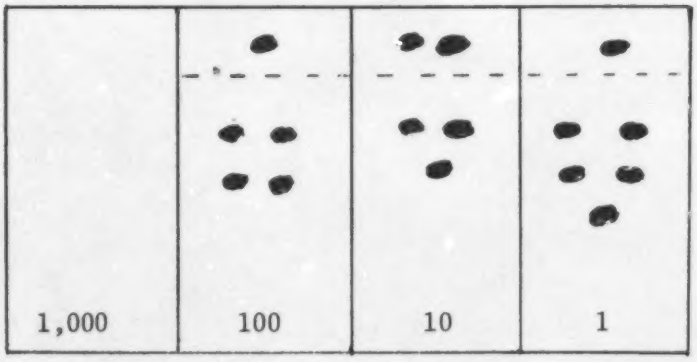
$$9 - 6 = 3.$$

We begin with a discussion of the easy case of subtraction without borrowing. Suppose one wishes to subtract 556 - 121. Begin by placing counters representing 556 on the abacus:

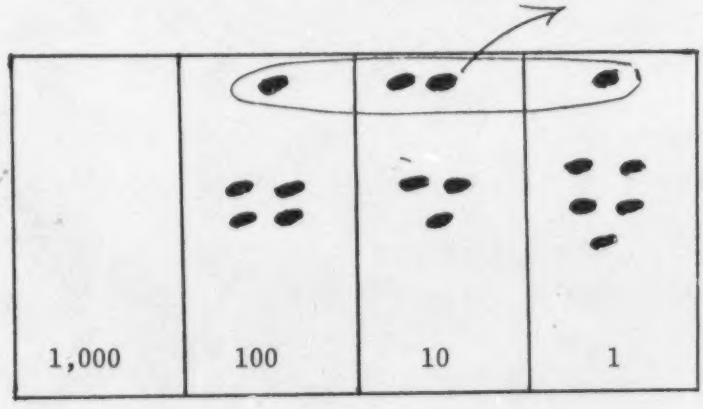


556

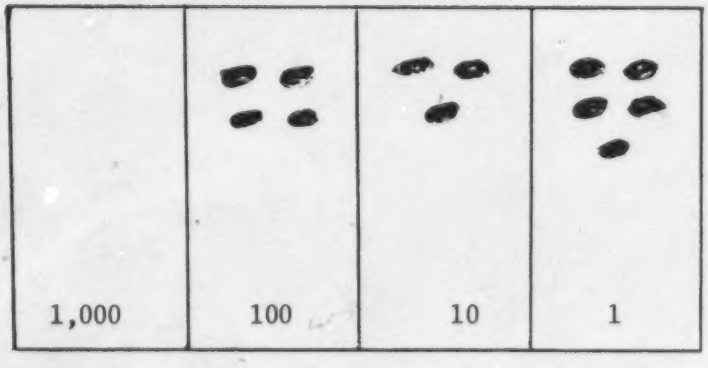
Secondly, partition them into two groups, one representing 121 and the other "the rest."



Finally, remove the counters representing the number 121 and "the rest", in this case 435, is the answer of the subtraction problem.



556 - 121

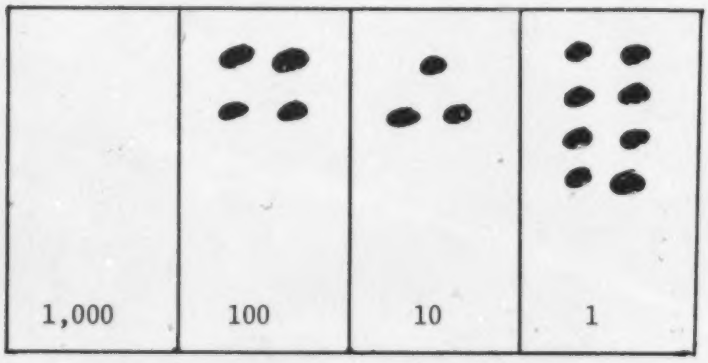


Once again, students should write out each problem which they work on the abacus:

$$\begin{array}{r} 556 \\ -121 \\ \hline 435 \end{array}$$

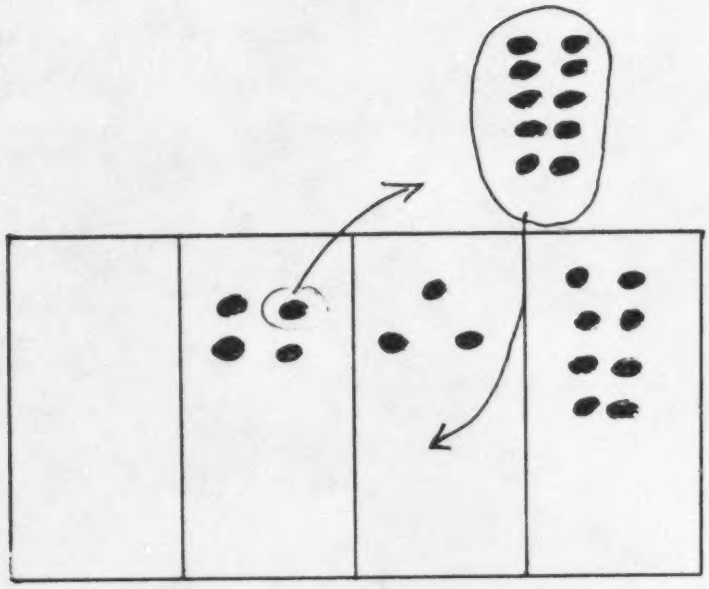
Finally we treat the topic which has the potential to baffle beginning students of arithmetic: subtraction with regrouping or borrowing. Happily, this process is the inverse of addition with renaming or carrying and a student who has mastered this on the abacus should be able to deal with the former. Rather than dealing with the subject in general or touching all special cases, we shall show how one particular example can be done.

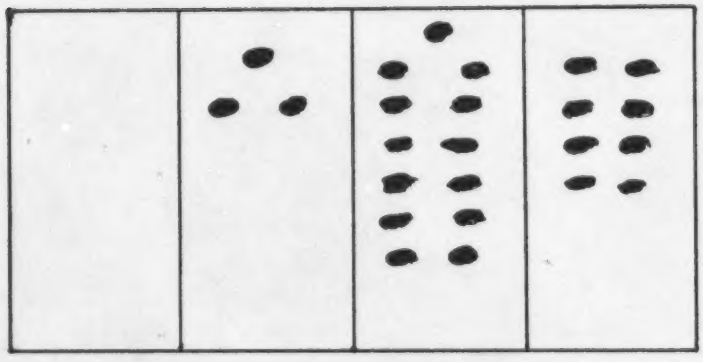
Suppose one wishes to solve on the abacus the problem 438-172 = ?. Begin by placing counters with value of 438 on the abcus:



438

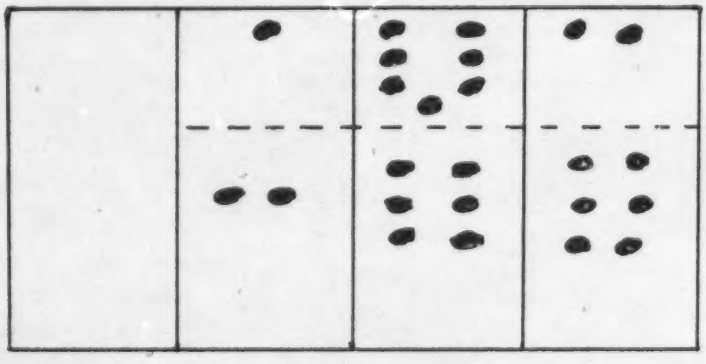
Now if one tries straightforwardly to remove counters with a value of 172, there is a hitch; there are only 3 in the ten trough and yet one has to remove 7. The solution, of course, is to remove 1 counter from the hundred trough and replace it by 10 more in the ten trough. This results in no change in the value of the number being represented on the abacus.



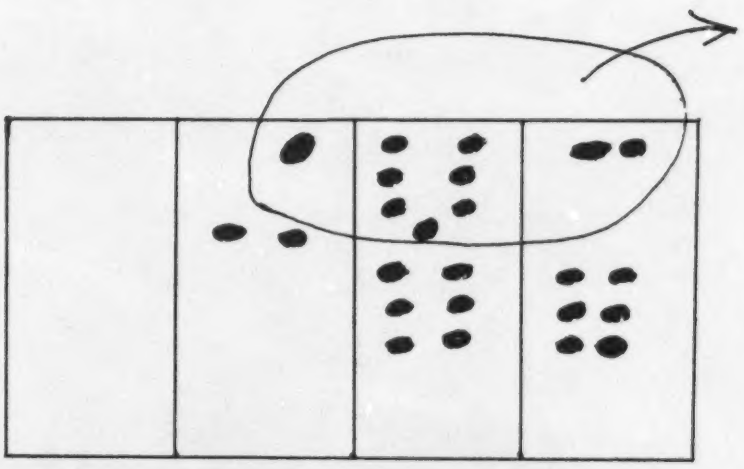


3 13 8

Finally, now, one can proceed as before with the subtraction. First partition the counters into two groups, one with value 172 and the rest.

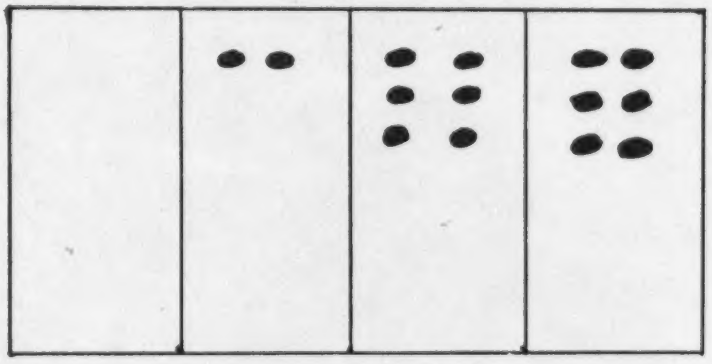


Next remove the counters representing 172.



438 - 172 = 3 13 8 - 172

The answer is the number remaining on the abacus:



266

As always, the student should write out the problem after it has been solved using the abacus:

$$\begin{array}{r} {\scriptstyle (3)} \\ \not{4}\ {\scriptstyle (1)}3\ 8 \\ -1\quad 7\ 2 \\ \hline 2\quad 6\ 6 \end{array}$$

6. Vocabulary for the Bi-Lingual Classroom.

The reader is referred to an earlier publication of the Washington State Migrant Education Center entitled "A Brief English-Spanish Vocabulary for School Mathematics." Vocabulary specific to the use of the abacus follows; it is arranged so that words or phrases corresponding to a particular section of this "User's Guide" are listed under the same part number below.

2.

abacus - el ábaco

to fold - doblar, plegar

dotted line - la línea de puntos

bean - el fríjol

stone - la piedrita

button - el botón

3.

put two beans in the one trough - pongan dos frijoles en la batea (la canoa) de las unidades (said to several students).

these beans have a value of eleven - estos frijoles tienen un valor de once

put beans with a value of thirteen on your abacus - pongan frijoles con un valor de trece en sus ábacos (said to several students).

4.

leave those beans on your abacus - dejen esos frijoles en sus ábacos (said to several students).

write down the problem - escriban la cuenta (said to several students).

to take away - quitar

to carry - llevar

take away these ten beans and put one here - quite estos diez frijoles y ponga uno aquí (said to one student).

the value is still the same - el valor es todavía igual.

you can't write down the answer if more than nine beans are in a trough - no se puede escribir la respuesta si mas que nueve frijoles estan en una batea (una canoa).

5.

take away beans with a value of 123 - quiten los frijoles con un valor de 123.

what is the value of the beans on your abacus - qué es el valor de los frijoles en tu ábaco , (said to one student).

separate the beans into two groups, one with a value of 123 - separen los frijoles en dos grupos, uno con un valor de 123 (said to one student).

it isn't possible to remove seven beans if there are only two in the trough - no es posible quitar siete frijoles si no hay más que dos frijoles en la batea (la canoa).

to borrow - prestar (students educated in Mexico don't "borrow", they "loan", another way of looking at the same thing.)

1000 MILLARES

1000 THOUSANDS

100 CENTENAS

100 HUNDREDS

10 DECENAS

10 TENS

1 UNIDADES

1 ONES

18

20